# Need for Cross-scan information

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## 1 Introduction

Recently there has been discussion regarding the need for *cross-scan* information for the majority of FAME stars. All parties agree that this information is required for a sub-set of stars used to determine spacecraft attitude. Therefore, I will not re-state the need for these data. In this paper I am specifically addressing the remaining stars, which I will call *field stars*.

## 2 The problem

As the instrument rotates, the images being clocked in TDI mode reach the edge of the CCDs. The pixelized data are analyzed and the time which the center of each image reached the CCD edge is one of our measurements. These timings will eventually be used to determine angular separations between stars.

In the idealized case where the FAME spacecraft sweeps out a perfect great-circle and the CCDs are perfectly aligned, then the cross-scan information would not be needed. Timings and spacecraft attitude are all that are required to determine angular separation between any stars. However, we have a continuously precessing instrument. Given the current design of precessing about 0.5 degree per rotation, the angle between the CCDs and the axis of rotation will be a nominal 4.8 minutes of arc. Note that this effect is not caused by CCD misalignments, but by the precession. Other dynamic effects will certainly add or subtract from this for short periods of time. It is this offset that will translate into an *along-scan* error if no cross-scan information is attained.

The amount of error in the cross-scan direction, $\delta y$, translates into an error in the along-scan direction, $\delta x$, by the formula

$$\delta y \times \tan\theta = \delta x \tag{1}$$

where $\theta$ is the angle between the CCDs and the axis of rotation. This is shown in the attached figure. In the upper panel, the angle between the axis of rotation and the focal plane is zero. All stars, that leave the CCD at the same time have no angular separation wrt the coordinate system defined by the axis of rotation and the plane being swept out. Lack of knowledge in the cross-scan direction does not translate into the along scan error. In the lower panel, there is a rotation. Now lack of knowledge in the cross scan coordinate translated into an along scan error, and is a function of $\theta$. Stated again, nominally $\theta$ is about 5 minutes of arc. Note that I am assuming that $\theta$ is know perfectly. Therefore this is not an argument of which reduction method to use, CfA vs. USNO,

for example. Using $\theta = 4.8$ arc minutes, and 206 mas/pixels, the errors are as follows:

| cross-scan error | resulting along-scan error |
|---|---|
| 0.029 (1/35) pixel | 8 uas |
| 0.5 pixel | 144 uas |
| 1.0 pixel | 288 uas |
| 3.0 pixels | 863 uas |

# 3 Solutions

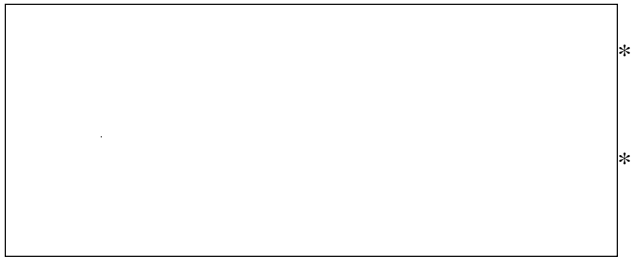
As shown in the table, these errors for the present design of FAME are non-trivial and should not be ignored. With no knowledge in the cross-scan direction, we are effectively using the input catalogue for this information. There may be some solutions to this problem.

**Send more pixels down per star.** The binning that is planned in this coordinate was implemented to save on the telecom rate. If we find we can increase our telecom rate or have more bits/star than is currently envisioned, this is our best bet.

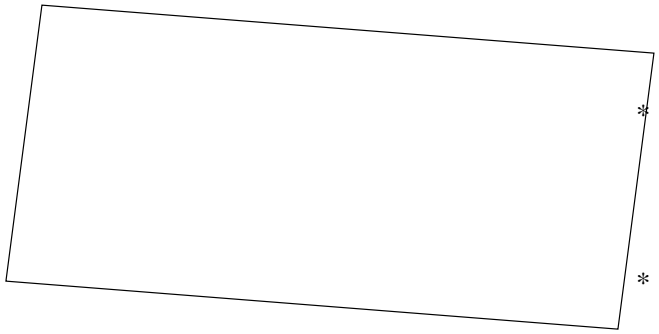
**Use back-substitution.** As we observe more, our knowledge of the location of each star increases. As of now, we do not know how quickly and to what accuracy this will converge. It remains To Be Determined. This will be a non-trivial task, but it may work.

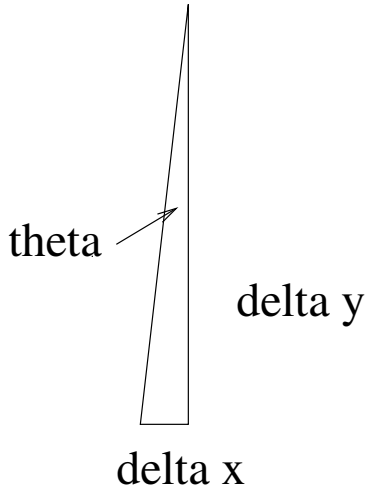
**Do not observe field stars every opportunity.** Sending down more pixels per field star observation, but not each time they are observed, will save in telecom at the expense of observations. I only suggest this as a possible solution; it is the one I like the least.

Need for Cross-scan information due to angle between CCDs and axis of rotation



Theta = zero;  no correction






Theta not equal zero; need correction